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Experiments in the use of Culicide for mosquito destruction.

Passed Assistant Surgeon Berry, at Tampa Bay Quarantine, reports as follows, under date of January 20, on experimental work in mosquito destruction with the vapor produced by the heating of the mixture of carbolic acid and camphor, known in New Orleans as "Mims' Culicide," so named because Professor Mims of that city first suggested its use:

Some experiments, conducted during the progress of the epidemic in New Orleans, by generating "Mims' Culicide" under pressure in a retort, proved, I believe, rather unsatisfactory. Shortly afterwards I was ordered to Gulfport, Miss., for special duty under Surgeon Wasdin, and while awaiting orders at that point I witnessed the practical use of this culicide, which had already been widely and successfully used by Surgeon Wasdin.

I observed two methods of evaporation of the liquid which I shall call for brevity "Culicide." One was evaporation over a kerosene stove. I was not favorably impressed with this method, since during the demonstration, kindly given by Doctor Scheele at his own home, the stove did not work properly. The flame leaped over the pan of Culicide and the liquid, blazing up, filled the room with dense smoke which settled down as a soot.

The other method of evaporation of Culicide, used by the postmaster of Gulfport, Mr. Braxelton, struck me at once as being simple, inexpensive, and safe. Mr. Braxelton used the apparatus for periodical fumigations of his own home, and invited me to attend one of the fumigations. His apparatus consisted of three small alcohol lamps, the familiar "Bolide" vapor lamp being used. These were set on the floor in different parts of the house. Over each was placed vertically an 18-inch length of ordinary stovepipe of about 6-inch diameter. On the top of the stovepipe was placed a pan containing several ounces of Culicide. After placing everything in position and lighting the lamps, he closed the doors of the house, leaving the house with no one to watch it. At the end of an hour and a half we returned and found that the Culicide had evaporated, and that the results were successful.

I returned to New Orleans shortly afterwards, determined to use Culicide if opportunity was given me. This soon took place when

I was given charge of the lower ninth ward. I at once requisitioned for stovepipe, alcohol lamps, and 5 gallons of Culicide. I was supplied with a carboy containing 4½ gallons, which had been obtained from the mixture of 20 pounds each of camphor and carbolic acid crystals. With regard to the cost of the ingredients, the carbolic acid, at practically wholesale prices, cost 22 cents per pound, and the camphor 80 cents per pound. The total cost of the 4½ gallons was therefore $20.40, and including the cost of labor to mix it about $22. The cost of 1 ounce of this 4½ gallons is less than 4 cents. I have been told that because of the recent Russo-Japanese war the price of camphor is unduly high, in fact is quadruple the value it held prior to the war. In case camphor should fall in price to 40 cents per pound, the cost of the mixture would be only 2 cents per ounce. The cost of the carboy of Culicide was less than that of a 100-pound barrel of pyrethrum, then quoted at 25 cents per pound. It is stated that a large part of the pyrethrum on the American market has been heavily adulterated with camel's dung.

I used Culicide experimentally in one of the back rooms of my ward headquarters before giving it out for use in houses and learned several important facts:

(1) That it was necessary to perforate the stovepipe with airholes above and below for the free burning of the lamp.

(2) That the confined heat in the bottom of the stovepipe is too great for alcohol lamps, one of them having its legs melted off. Accordingly large sections were cut out of the bottom of the pipe, so that only enough of the pipe was left to form legs in shape of a tripod. The sections were cut out to a height opposite the burner.

A further improvement would have been to attach by brads 3 or 4 small legs of iron rod similar to those forming the legs of a tripod for a pharmacist's water bath. In that case there would have been no confined or reflected heat, all the heat not going up the natural chimney formed being harmlessly dissipated in the air. For practical purposes the mere cutting out of sections, leaving only a width of 1 inch or less for the sections left in as legs, proved sufficient.

(3) The lengths of stovepipe were successively shortened from 18 inches to 8. When a shorter length than this was used the heat was too great and the mixture caught fire.

(4) As a further safeguard the alcohol lamp was placed in a tin dairy pan containing a half inch of water. Then in case of any leak of the alcohol lamp it would burn out harmlessly. The water came up just to cover the lower soldered portions of the lamp, and thus prevented it from becoming overheated. The stovepipe used was of galvanized iron. The air holes, numbering half a dozen, were about one-fourth inch in diameter and placed about one-half inch from the top. Without these air holes the flame would be sucked up into the pipe and burn irregularly. With the pipe fixed as described the flame burned steadily and strongly, practically all the heat going up the natural chimney formed, and evaporation took place rapidly when the pan containing Culicide was placed over the top.

(5) Several shapes of pan were tried, but an ordinary granite wash basin proved to be the best adapted to the purpose. It was substantial, did not scale or crack from the heat, there was no chemical action with the liquid, and the outside rim at the bottom just fitted the stovepipe, insuring steadiness and also evaporation of every drop of the

Culicide. This total evaporation did not occur when other pans, such as baking pans, were used, but some of the liquid ran to the edges of the pan, beyond the action of the heat from the stovepipe. For this reason the style of pan used is of importance.

Culicide was used in quite a number of houses in the lower ninth ward, and was used at first only as a substitute for pyrethrum; that is, in the homes where there were many articles of fabric or furnishings liable to be damaged by sulphur. It was also used for preliminary fumigation where there were sick in the house and the leaky condition of the building precluded the use of sulphur. For preliminary fumigation Culicide has advantages over either sulphur or pyrethrum.

Culicide, for instance, can be evaporated in a room in 20 minutes, and at the end of the time the room can be entered, the Culicide apparatus removed, and the mosquitoes and other insects swept up and destroyed. In such cases the expedient was used of placing sheets under one window left light, while other windows were darkened by shades or blinds. In this way the majority of the mosquitoes were on the sheet, not dead, but entirely stunned or incapable of flying.

Had pyrethrum been used it would have had to burn two hours in order to bring down all the mosquitoes, and had the house been one of loose construction the fumes would have reached the sick.

Sulphur can be depended upon to bring down the mosquitoes in as short a time but it is not subject to as easy control; the room can be entered with difficulty, or not at all, to remove apparatus. For this rapidity alone, to say nothing of its less disagreeable effects on the sick and of its harmlessness to fabrics and furnishings, I regard Culicide as the most desirable agent for preliminary fumigation.

After working experience had shown that Culicide in the proportion of 3 ounces to the 1,000 kills *Stegomyia*, it was used as a substitute for sulphur in certain houses selected for experiment. A room (cubic capacity 4,000 feet) in a house in the upper ninth ward was fumigated by my men at the request of Passed Assistant Surgeon Amesse. Because of the lateness of the afternoon, the room was opened in one hour and fifty minutes by Doctor Amesse's men and all mosquitoes and flies were collected from sheets on the floor and saved for examination the next day. I was informed by Doctor Amesse that none of the mosquitoes or flies revived.

The close of the fever campaign in the latter part of October ended the practical house-to-house work under my supervision. However, my Culicide gang was turned over to Passed Assistant Surgeon Blue in the upper part of the city, where it did satisfactory work for him.

I had performed experiments and made demonstrations with Culicide in one of the rear rooms of the lower ninth ward, but it was highly desirable that exact knowledge of the precise quantities of Culicide for effective work be known. For this reason I requested Passed Assistant Surgeon Goldberger of the Service to take charge of and conduct the more careful experiments which I wished made.

A large room at the marine hospital was placed at our disposal by Surgeon Smith, and thereafter all experiments were conducted in that room. A plentiful supply of the pupæ of *Culex pungens* were obtained from a drain leading from an abattoir, and after these had been hatched and fed several days on syrup to increase their resistance the experiments were begun November 2, 1905. The room used, which was one with quite a high ceiling (15 feet 8 inches), and with projec-

tions and offsets, contained 4,029 cubic feet. The room was furnished with a stove, cot, washstand, and chairs. The detailed experiments are as follows:

Experiment No. 1—November 2, 1905.

Temperature, 70° F. Quantity of Culicide used, 16 ounces, i. e., 4 ounces per 1,000 cubic feet, in two basins. Length of stovepipe, 8 and 8½ inches, respectively. *Culex pungens* previously mentioned fed on syrup for 24 hours distributed in three cages—one on the ceiling, one on the floor, and one midway between. Several other mosquitoes were liberated beneath the mosquito bar on the cot and others liberated in room. The three windows of the room were nearly closed and strips of gummed paper were used on cracks of doors, which were rather large. Lamps were lighted at 3.20 p. m., evaporation started at 3.25 p. m. Loose insects in the room ceased their efforts to escape at the window at 3.35 p. m. All of the liquid was vaporized at 3.47 p. m. The room was fairly filled with fumes at the expiration of vaporization. These gradually became less dense after the cessation of vaporization. At 4.20 p. m. the room was quite clear, the fumes having been dissipated. At the end of 2 hours the room was clear of visible fumes, but the air of the room was very irritating to the eyes. The tops of the cages were moist with precipitated Culicide. In the top cage, containing 10 insects, and in the floor and middle cages with 6 insects each, there was no life. All insects on the window sills, on the floor underneath, and on bed beneath the bar were dead. The cages used were of very close mesh copper bronze wire, about 24 meshes to the inch, with metallic tops and bottoms. None of the insects in the cages revived after keeping 16 hours in the cages in a room warmed to 82° F.

Experiment No. 2—November 3, 1905.

2.50 p. m.; temperature, 78° F. Two basins used, 4 ounces to each basin, and 2 ounces to each 1,000 cubic feet. One lamp burned high and vaporization ceased in 8 minutes. There was the same cloudiness of air as in the other experiment. Vaporization ceased in second pan at 3.08 p. m. At 3.12 p. m., or 4 minutes after completion, the cloudiness was distinctly less dense, and the air practically clear at 3.19 p. m., or 29 minutes after the process had started. The room was opened at 4.50 p. m. with this result: Ceiling cage, 12 insects, no life; mid-air cage, 12 insects, no life; floor cage, 12 insects, no life.

Behind the bar there were 6 insects, 1 or 2 showing signs of life. One tried to fly, but failed after several minutes' exposure to fresh air. Free insects inside the bar over the bed were all motionless on the bed. The air of the room was irritating to the eyes as before. The floor was slightly sticky but there was no visible moisture.

Experiment No. 3—November 4, 1905.

2.14 p. m., temperature 74° F. *Culex pungens*, 12 in each cage; common house fly, 4 in each cage. Culicide in strength of 3 ounces per 1,000 cubic feet, cages as before. Vaporization ceased in one pan at 2.26 p. m.; in the second pan at about 2.29 p. m., the time of exact stoppage not being discernible because of the dense fumes generated. At the end of 2 hours none of the mosquitoes in the cages gave signs of life.

In the floor cage 3 of the 4 flies showed signs of life; their legs moved feebly. All other flies seemed lifeless. The floor of the room was somewhat sticky. In the cage against the ceiling the insects adhered to the bottom of the cage; the surface of the cage showed slight moisture. After 16 hours' exposure all the insects were dead, including the 3 flies previously mentioned.

Experiment No. 4—November 5, 1905.

10.34 a. m., temperature 80° F. Quantity used, 3 ounces per 1,000 cubic feet. Cages contained *Culex pungens* and house flies, as in previous experiment. Vaporization ceased at 10.47 a. m. in one pan and at 10.50 in the second pan. Exposure 1 hour, until 11.34 a. m., with results as follows: In the floor cage, containing a great number of *Culex pungens*, the mosquitoes were all dead; the flies showed faint signs of life. In the cage behind the mosquito bar the *Culex pungens* were lifeless, the flies very feeble. There was the same result in the mid-air cage. In the ceiling cage all were dead.

Experiment No. 5—November 6, 1905.

1.45 p. m., temperature 70° F.; a rainy day. No cages were used, but a number of *Culex pungens* and *Anopheles* were liberated in the room. After exposure for 1 hour with 3 ounces to 1,000, there were no insects on the wing, and most of the insects on the floor were on a sheet spread under the windows left open to the light. A few insects made feeble attempts to move their limbs, particularly the *Anopheles*, which essayed short flight, after which they would tumble on their back.

Experiment No. 6—November 7, 1905.

2.12 p. m., temperature 70° F. Culicide 3 ounces to 1,000 cubic feet. Exposure 2 hours; vaporization completed in 15 minutes. Results as in previous experiment. A few of the *Anopheles* showed feeble signs of life; some of them picked up from the white cloth near the window, and kept for 17 hours, showed slightly increased animation, one still being able to fly.

Experiment No. 7—November 13, 1905.

1.34 p. m., temperature 66° F. Culicide, 4 ounces to 1,000 cubic feet; 16 ounces placed in one basin over one lamp and pipe. *Culex pungens*, *Anopheles*, and *Stegomyia* mosquitoes employed, as well as a few house flies. After 2 hours all the liberated insects on the floor were apparently lifeless. Those in the cages were in the same condition. After 17 hours all the insects were dead except 2 flies on the floor, which made feeble attempts at flight.

The experiments were not carried further because of the continued cool weather and the need of the room for hospital purposes. It is regretted that a large number of *Stegomyia* mosquitoes could not have been obtained for the experiments, but the work of their destruction had been so complete in the city that a search for them would have been prolonged or possibly fruitless. Experiments at my ninth ward headquarters showed that *Stegomyia* succumb as easily as *Culex pungens*.

The action of Culicide on the insects is somewhat different from that of sulphur and has its own advantages. Insects when driven out of their hiding place by sulphur will intelligently try to get out of the room. They search for cracks and fresh air, flying especially for crevices where the light shines through. With Culicide there is no such effort to escape from room. The vapors intoxicate the insects and they buzz around the room until they fall suddenly. It is true that in a general way they fly toward the light, but this action is not as pronounced as when sulphur is used. Flies particularly show this intoxication. After being brought down they buzz around on their backs and sides, often getting up for short flights to fall again when they get into a higher stratum of air. Cockroaches do not show a tendency to intoxication as do mosquitoes and flies, but try to get out of the room through cracks. I have killed them in rooms, using 3 ounces to 1,000 cubic feet.

On man the effects are not as toxic as one would expect, considering that one of the ingredients is a lethal agent like phenol. During the demonstration given me at his home in Gulfport Doctor Scheele remained in his room during the whole process. I have experienced ill effects only once, and that was after being all day long in and out of rooms in the ninth ward which were being fumigated with Culicide. I experienced a feeling of nausea with free flow of saliva lasting half an hour. There is a feeling of numbness about the lips and pharynx after breathing the vapors for a short time. The Culicide liquid had no appreciable caustic action on the skin.

Referring again to the toxic action upon insects, I believe that it is not necessary to paste as much of the room as when using sulphur. Not only is this method a saver of time but it will arouse less opposition among householders.

As a result of the experiments Passed Assistant Surgeon Goldberger arrived at the following conclusions, with which I concur:

1. Culicide in the proportion of 4 ounces per 1,000 cubic feet used for 2 hours with apparatus similar to that used by us kills *Culex pungens*, *Stegomyia*, and *Anopheles maculipennis* and temporarily stuns the house fly.

2. In the proportion of 3 ounces to 1,000 cubic feet it does not always kill the *Anopheles maculipennis*.

3. Culicide takes fire spontaneously if heated sufficiently. It is therefore necessary to keep the liquid at a certain distance from the flame; it is also better to have more than one basin in a large space, and about 8 ounces is the maximum quantity to use in one pan. All large cracks must be pasted up—the doors and windows if loose fitting. Gummed paper spread under a window left light would be of great benefit. (I concur with Passed Assistant Surgeon Goldberger as to the closing up of large cracks, but more for preventing weakening of the strength of the gas in the room by diffusion than from any belief that insects might escape from the room.)

4. In the hands of intelligent operators, and used according to the methods employed by us, it ranks next to sulphur as an insecticide in practical fumigation.

5. Culicide vaporizes and later cools, condensing on exposed surfaces again as it cools. Whether in this way it injures articles of gilt and the like was not investigated. In practical work the only articles removed from rooms were food stuffs and animal pets and no complaint

of injury was received. It gradually evaporates, leaving a persistent, though not disagreeable, odor.

As to the cost with the present high prices of the ingredients of Culicide, the cost of fumigating a room with 4 ounces to 1,000 cubic feet is 16 cents per 1,000 cubic feet, as compared with sulphur of 7 cents, and pyrethrum of 50 cents, using 2 pounds of each of the latter per 1,000 cubic feet. The estimate does not take into consideration the alcohol used to evaporate the Culicide, but this is not much more, if any, than that used to ignite pyrethrum or sulphur pots. A further saving in favor of Culicide is that the apparatus can be easily carried in the hands from place to place. Had sulphur been used in the instances cited a wagon would have been necessary to transport the materials, which were, in the case of Culicide, conveyed in street cars. The gang would have had to be larger to move the many articles from a house necessary to be removed in sulphur fumigation, to say nothing of the larger amount of pasting to be done. Likewise at the end of the fumigation the time required to remove apparatus from the room is much less. For this and other reasons, if the cost of the labor is counted, I do not believe Culicide is much more expensive than sulphur, and if the cost of the articles damaged by sulphur is considered, the difference would be in favor of Culicide.

Yellow fever case at Kenner, La.

Passed Assistant Surgeon Corput, at New Orleans, reports, January 29, as follows:

One yellow fever case reported at Kenner yesterday.

Report from Vanceboro, Me.—Increase of smallpox on Canadian border—Precautions taken to prevent importation.

Acting Assistant Surgeon Young reports, January 22, as follows:

During the week ended January 21, 1906, 18 passenger and 14 freight trains, carrying a total of 739 passengers, were inspected at this port.

Of this number 26 were vaccinated; 1 was refused admission on his arrival at the nearest Canadian point. Owing to the difficulty of obtaining admission through this port from the infected districts along the line of the Canadian Pacific Railway very few persons attempt to come without previously opening correspondence with this office to ascertain if permission to cross the border will be granted.

After a temporary improvement in Sunbury and Queens counties the smallpox situation has again become worse. At Waterboro, Queens County, where the disease was supposed to be stamped out, several new cases were discovered on the 18th instant, and conditions indicate a further outbreak.

A personal letter this morning advises me of the recently discovered existence at Hoyt Station, on the direct Canadian Pacific Railway line to this port, of a severe type of this disease.

At Tracey, on the same line, there were discovered a few days ago 6 concealed cases in one house. Yesterday I was advised that this number had increased to 8.

No real effort has yet been made to stamp out the epidemic at Tracey. In its early stages the disease was mild, and its real nature unrecognized; churches and schools were attended by persons in all stages of